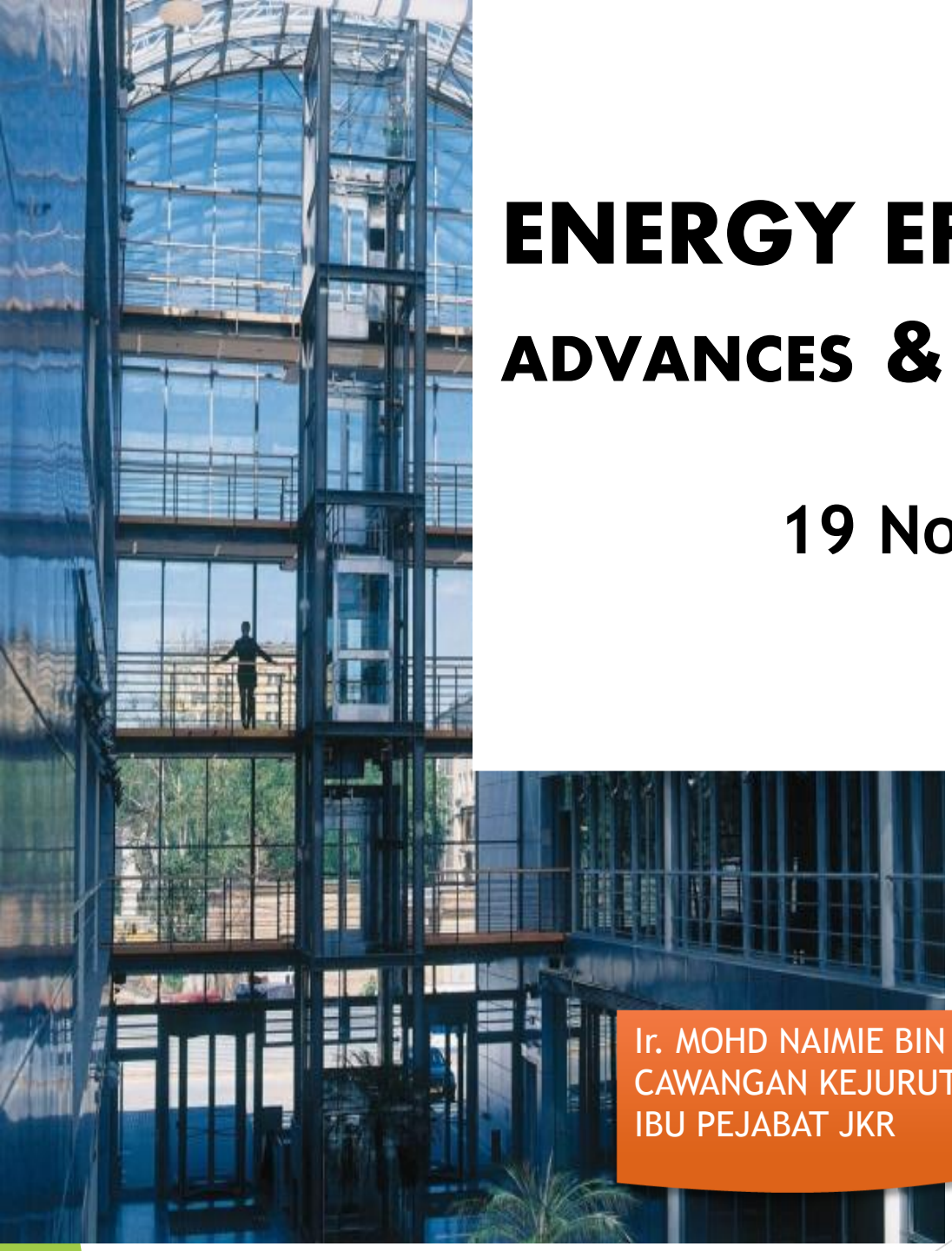

ENERGY EFFICIENT LIFT:
ADVANCES & STRATEGIES

19 November 2021

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CAWANGAN KEJURUTERAAN MEKANIKAL
IBU PEJABAT JKR

JKR

CONTENTS

OBJECTIVES

1. To raise awareness about the importance of energy efficient lifts.
2. To share various technologies and strategies that can be applied to acquire energy efficient lifts.

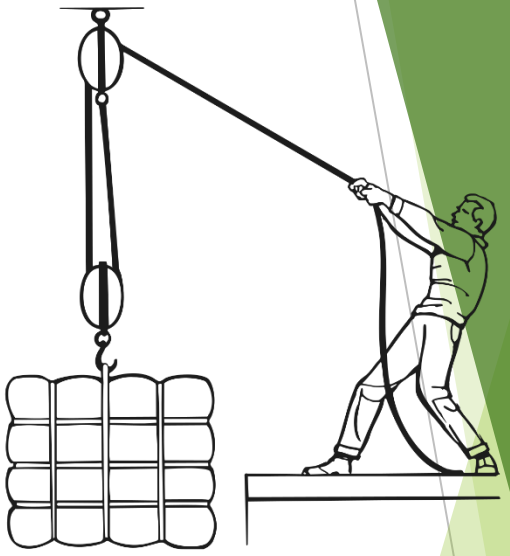
WHY NEED ENERGY EFFICIENT LIFT?

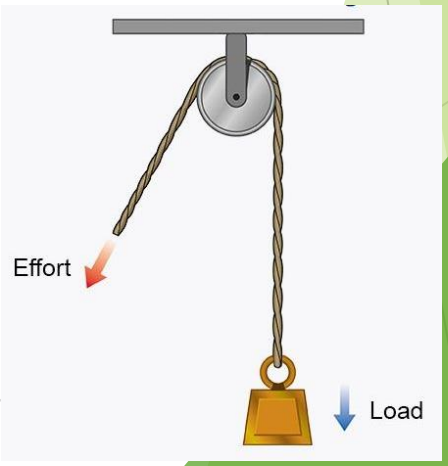
1. Financial savings - the cost of energy is increasing, need to reduce energy demand, operating costs, etc.
2. To safeguard and preserve our environment – reduce carbon footprint, greenhouse effect, etc.
3. To comply with the local and international pacts, policies, standards, such as Paris Agreement, Kyoto Protocol, National Energy Efficient Action Plan, Sustainable Development (2030 Agenda), MS 1525, etc.

INTRODUCTION TO LIFT SYSTEM

BACKGROUND

- Vertical transportation system – carry people, goods, etc.
- Known as lift in UK, elevator in USA.
- Common type: hydraulic & traction
- Basic concept – lifting objects with the assistance of pulley system





LIFT TIMELINE

- 1857: First steam driven lift installed by Otis Elevator Company in New York City
- 1878: First electric lift, invented by Werner Von Siemens in Germany
- 1887: First electric lift with automatic door
- 1889: First commercially lift installed

TYPES OF LIFTS

APPLICATION

PASSENGER

GOODS/ FREIGHT

VEHICLE

SERVICE

DUMBWAITER

TYPES OF LIFTS..

- LIFTING MECHANISM
  - TRACTION
    - GEARED
    - GEARLESS
  - HYDRAULIC
    - DIRECT ACTING
    - IN-DIRECT ACTING
  - PNEUMATIC

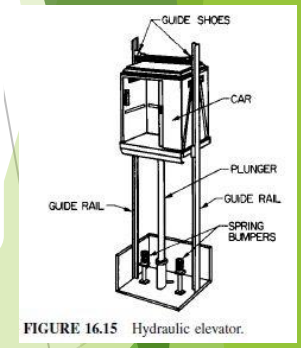
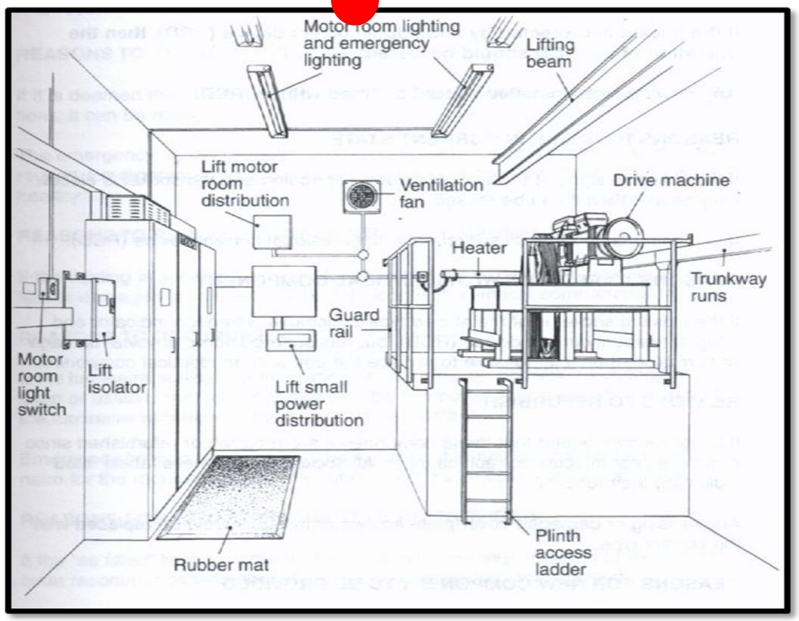
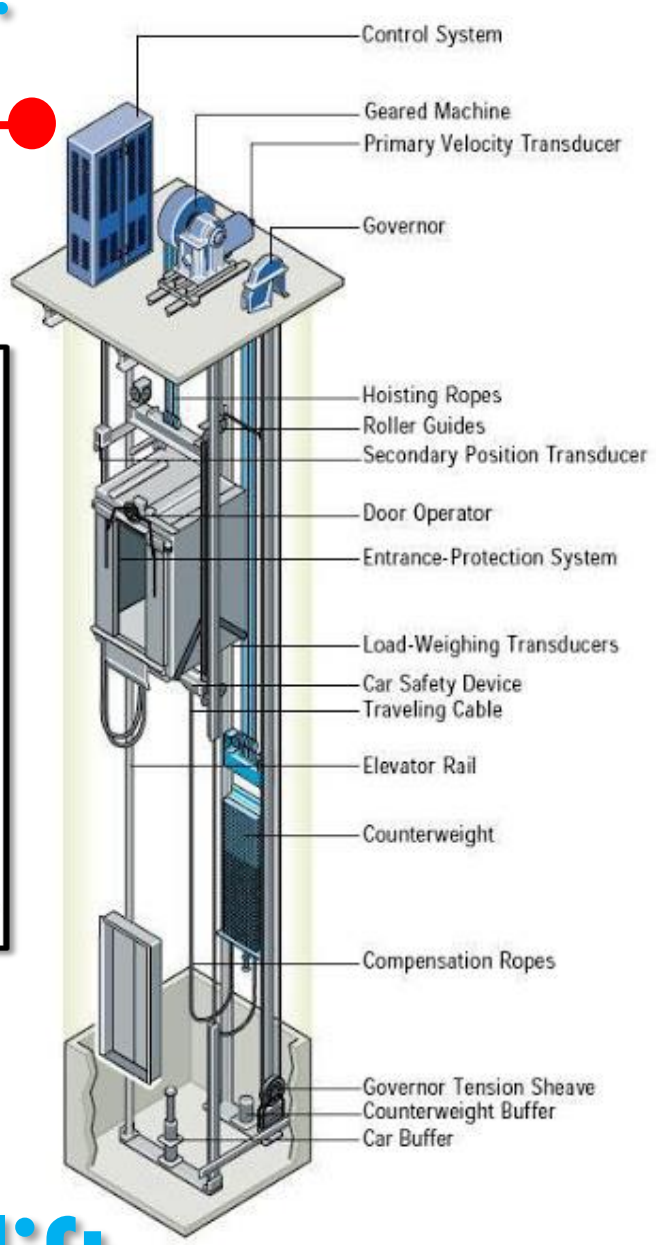


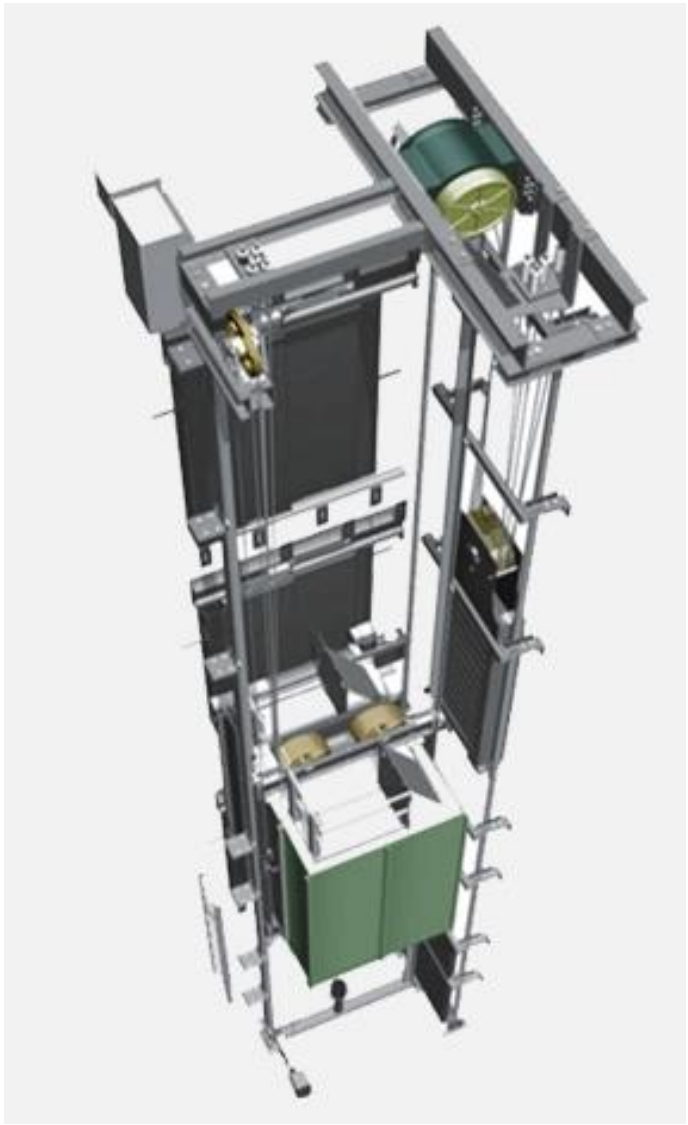
FIGURE 16.15 Hydraulic elevator.

TYPES OF LIFTS..





Machine room lift



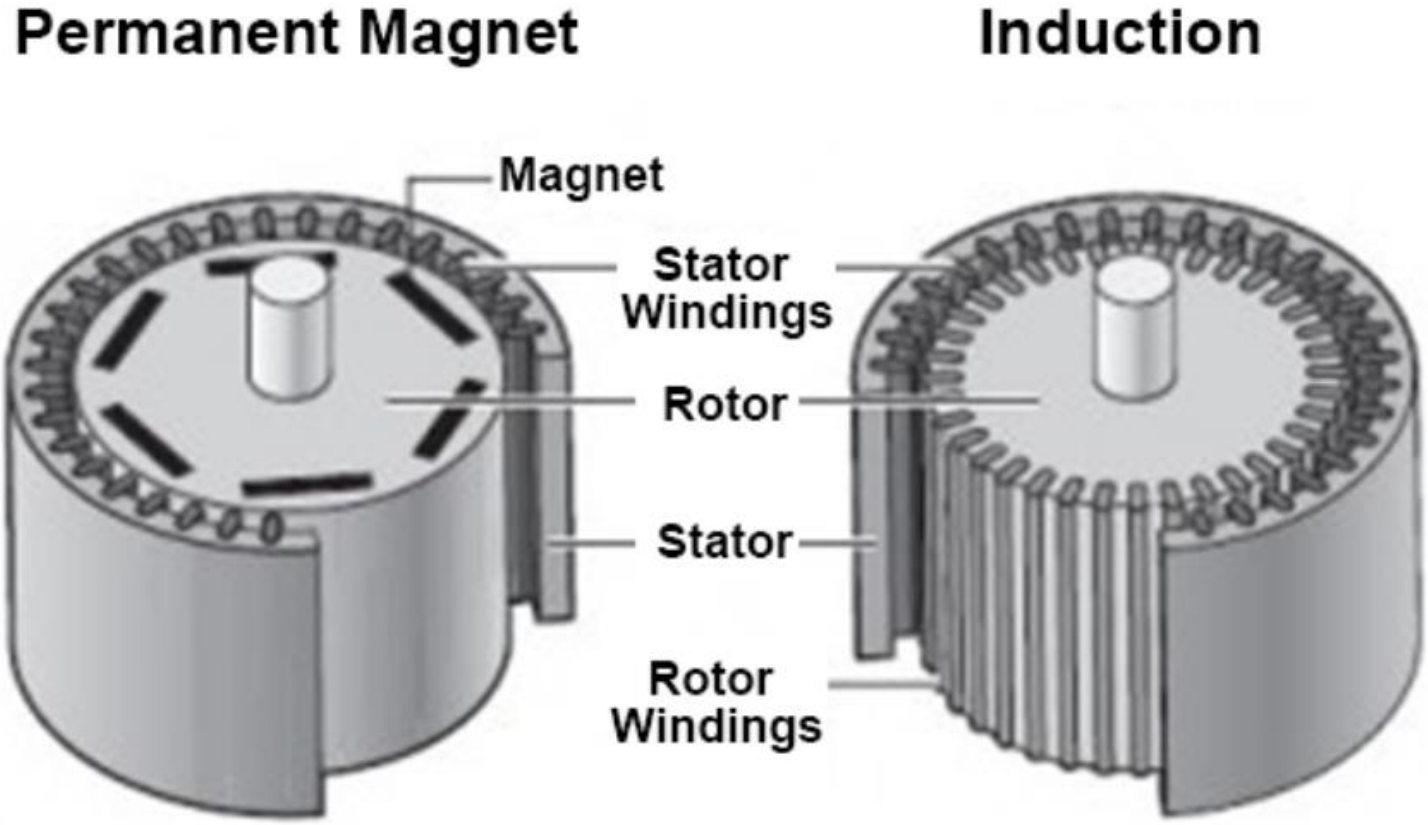
Machine roomless lift

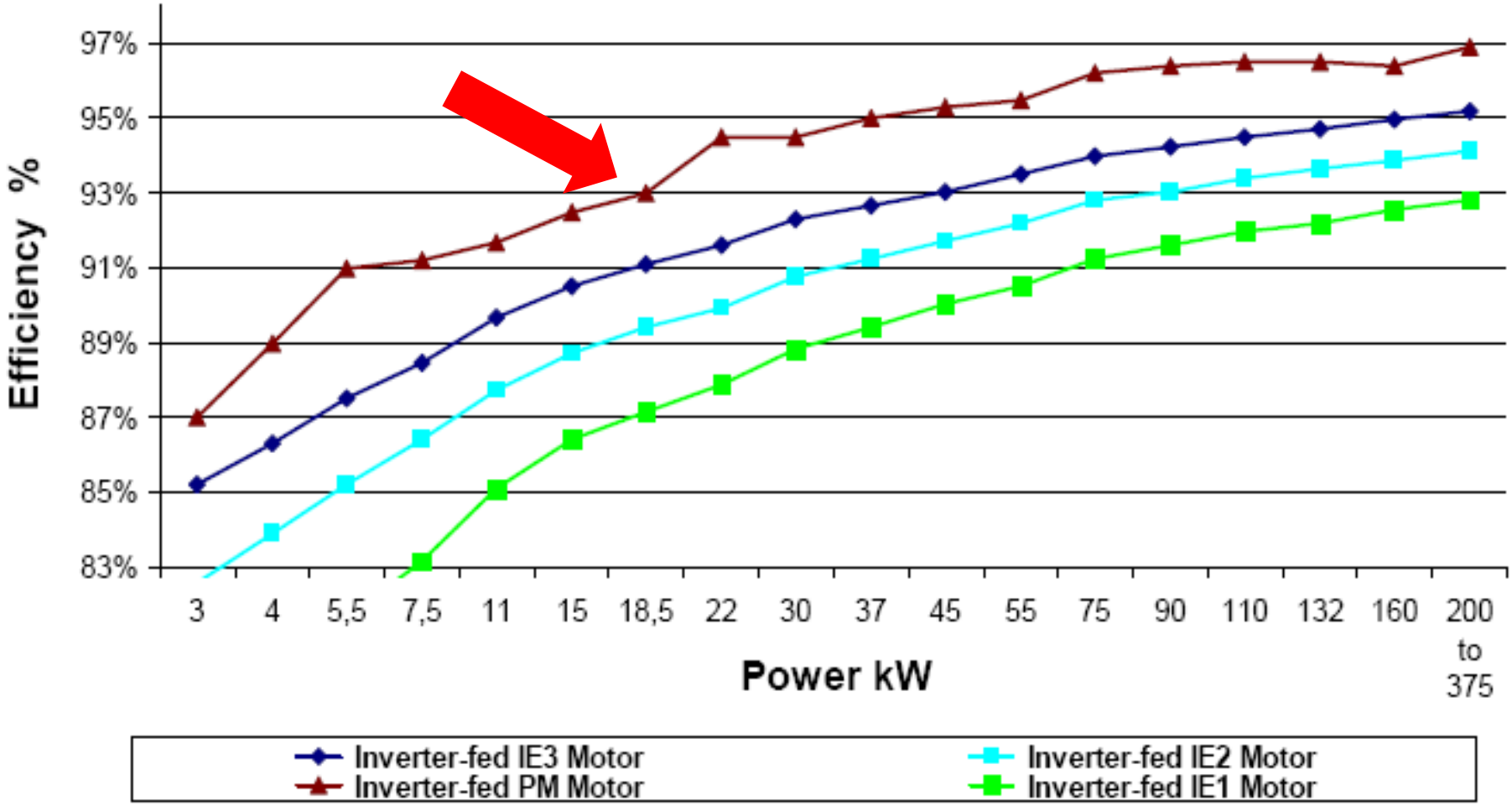
ADVANCES IN LIFT TECHNOLOGY

1. HIGH EFFICIENCY MOTOR

- **Motor efficiency ≥90%**
- **Minimum efficiency class - IE3 (Premium Efficiency)**
- **Permanent magnet synchronous motor (PMSM) – Class IE4 (Super Premium Efficiency)**

PMSM save energy by 30-50% compared to induction motor


Permanent Magnet
Induction
Magnet
Stator Windings
Rotor
Stator
Rotor Windings



Comparison of inverter fed induction and permanent magnet motor efficiencies (source: Leroy-Somer)

2. VVVF MOTOR DRIVE CONTROL SYSTEM

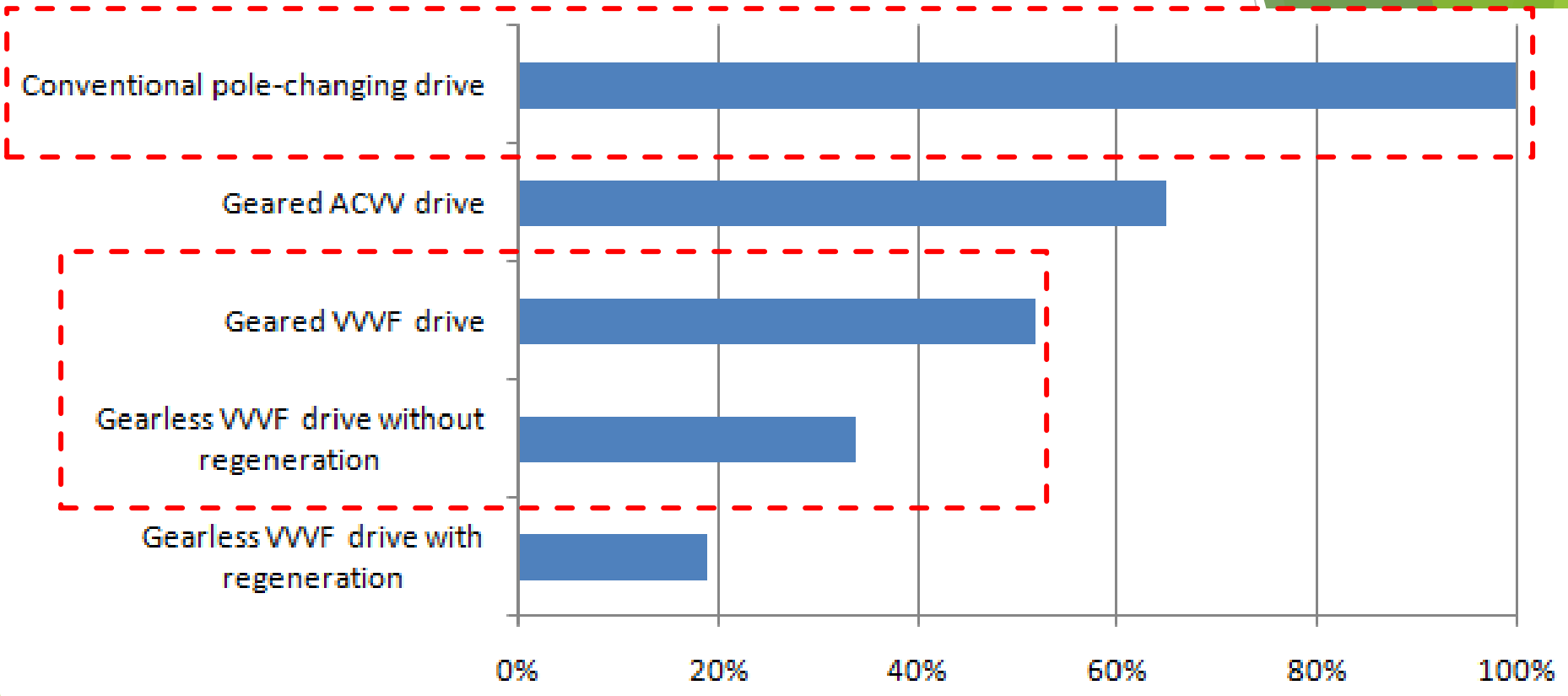
- To regulate speed and torque of the motor based on system demand
- Reducing energy consumption

VVVF MOTOR DRIVE MAIN COMPONENTS

1. **CONTROL**
- Keypad/ operator
- Set parameters (overloads, accel/ decel rates, min/max speed
- I/O terminal
- Control board – collect information and relays information/ tasks as required

2. **POWER**
- Separate the high and low voltage areas
- Monitor and control the drive

3. **MAIN CIRCUIT**
- Inverter (IGBT)
- Heavy transformation of power
- Convert AC-DC-AC



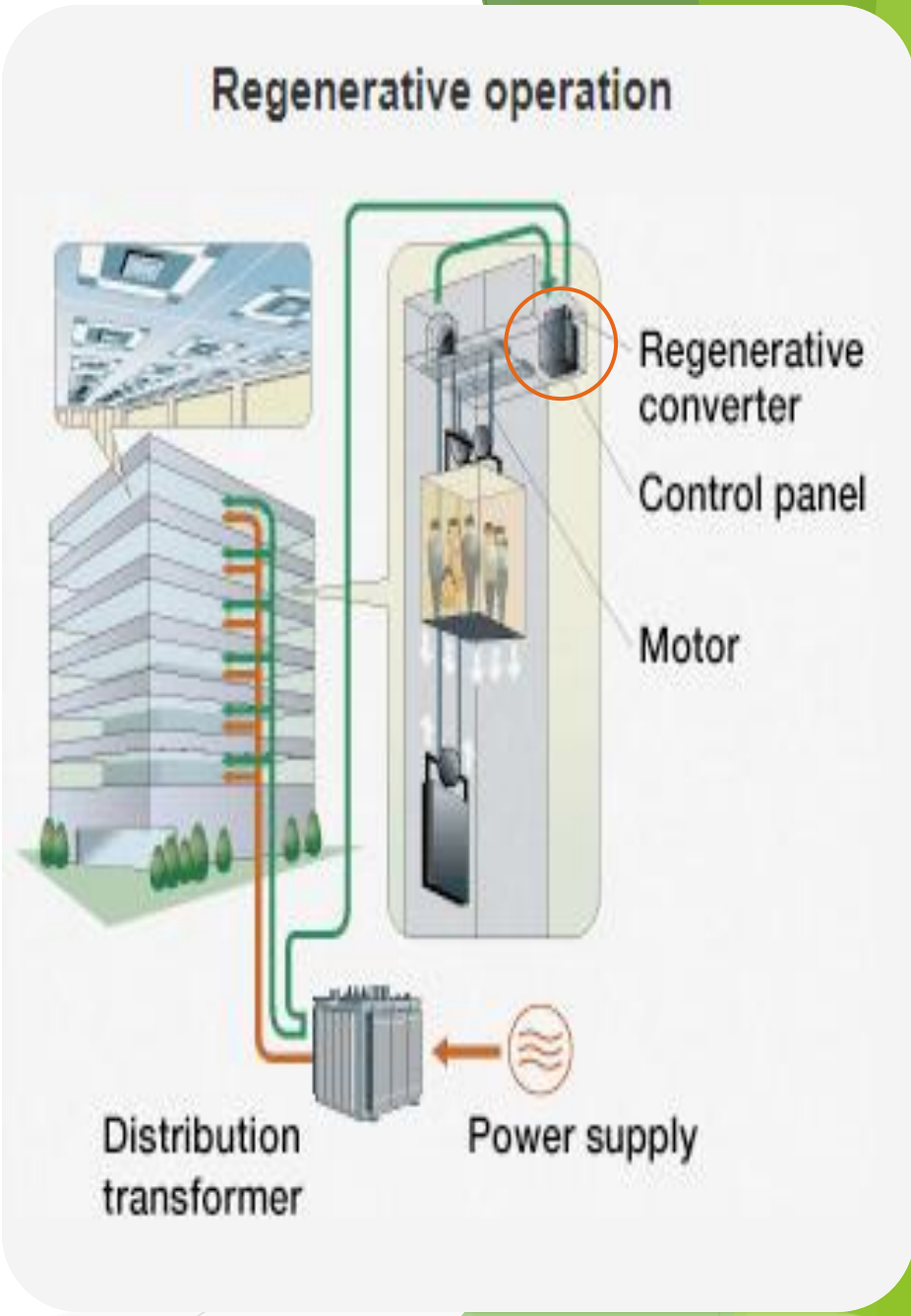
Average Energy Consumption(%)

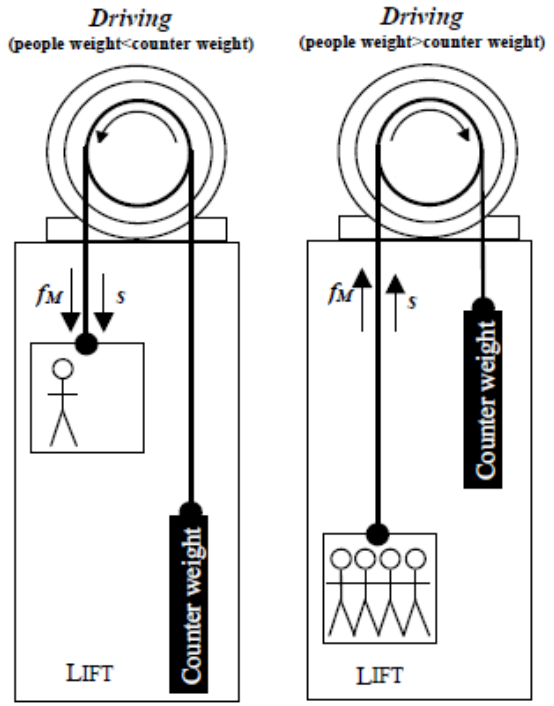
(source: flender-atb-loher, systemtechnik)

3. REGENERATIVE DRIVE SYSTEM

- Convert or store braking energy from a moving lift car.
- Stored energy can be used to energise lighting and ventilation system in the lift motor room.

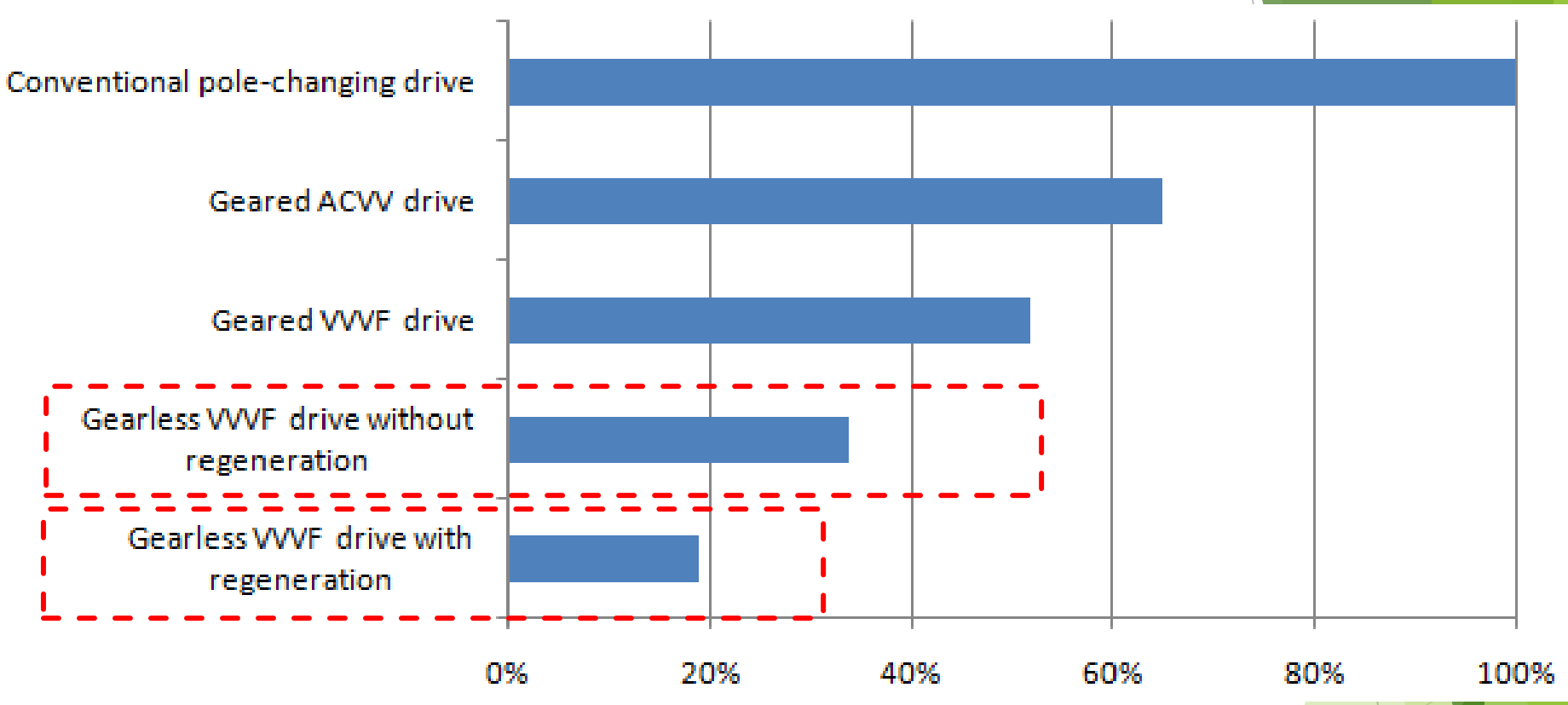
Drive	Regeneration capability
AC Single speed/ AC 2 speed	Yes
ACVV	No
DC thyristor	Yes
VVVF	Yes





Generating mode (energy back to mains):
(i) lift empty moving up
(ii) Lift full moving down

Up to 20% saving compared to VVVF elevator without regenerative drive.



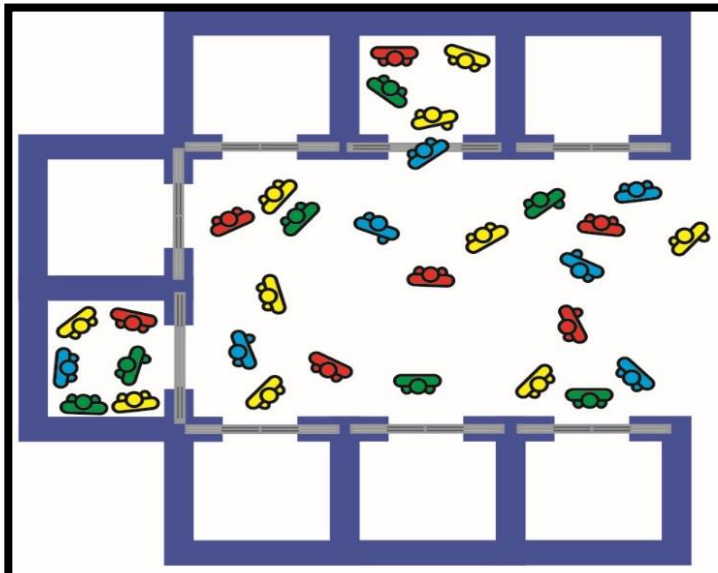
Average Energy Consumption(%)

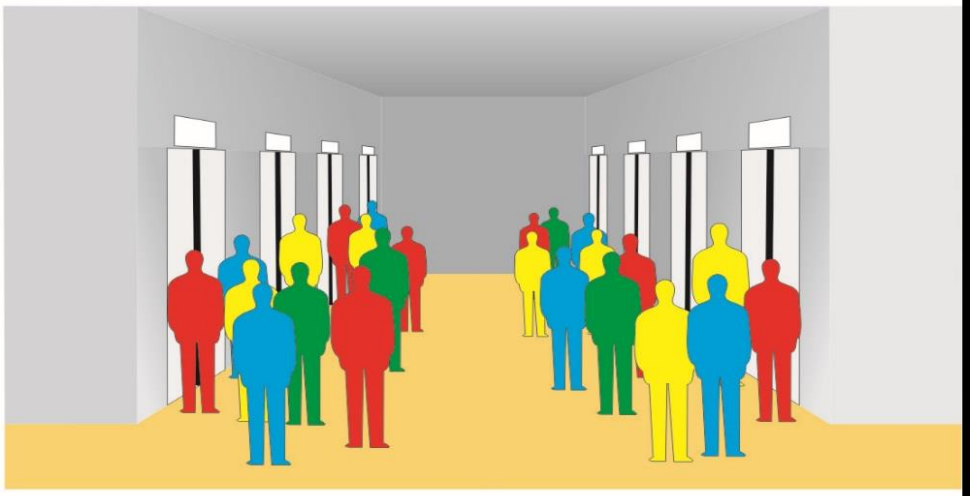
(source: flender-atb-loher, systemtechnik)

4. DESTINATION CONTROL SYSTEM (DCS)

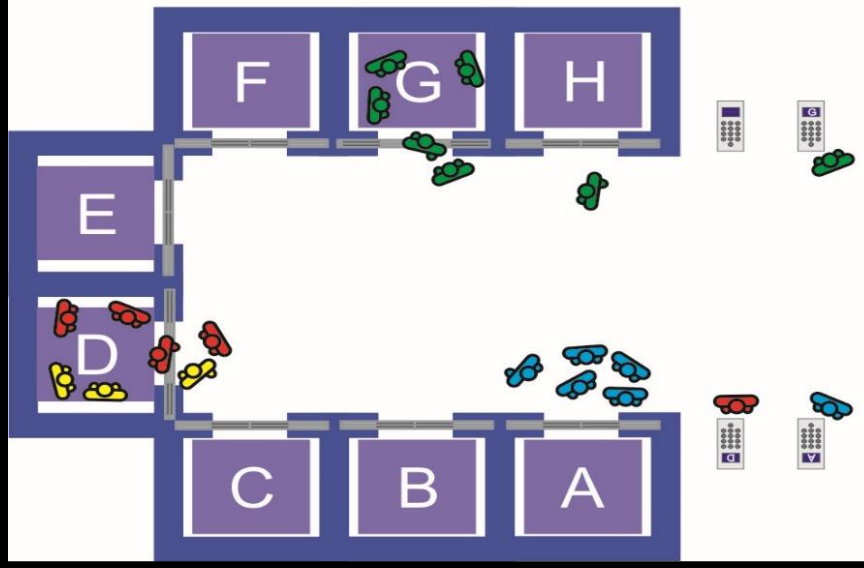
- Better traffic management control, especially for up peak handling capacity.
- Optimize lift operation, reduce number of stops – save energy.
- DCS knows the arrival floor and the destination floor of a passenger, and the exact number of passengers waiting at each floor. At the entrance floor, the control system gathers passengers with the same destinations in the same car. Thus the number of stops during the up trip can be reduced to decrease the round trip times.

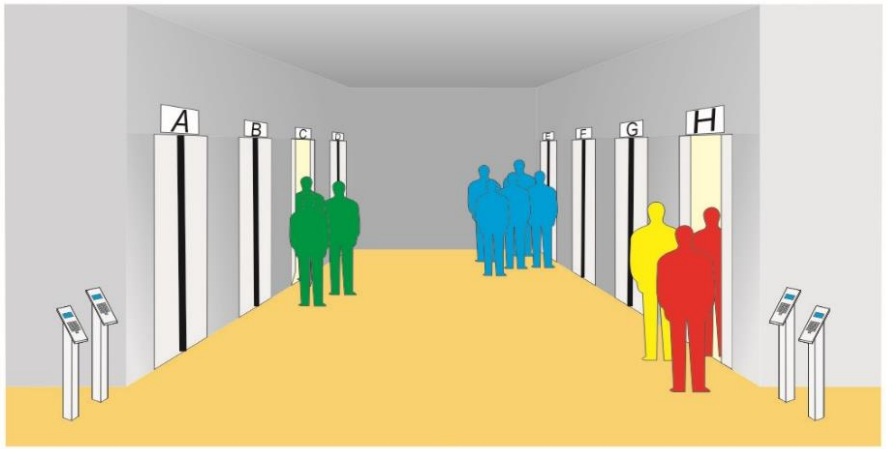
Courtesy of Otis Elevator Company





Conventional control system

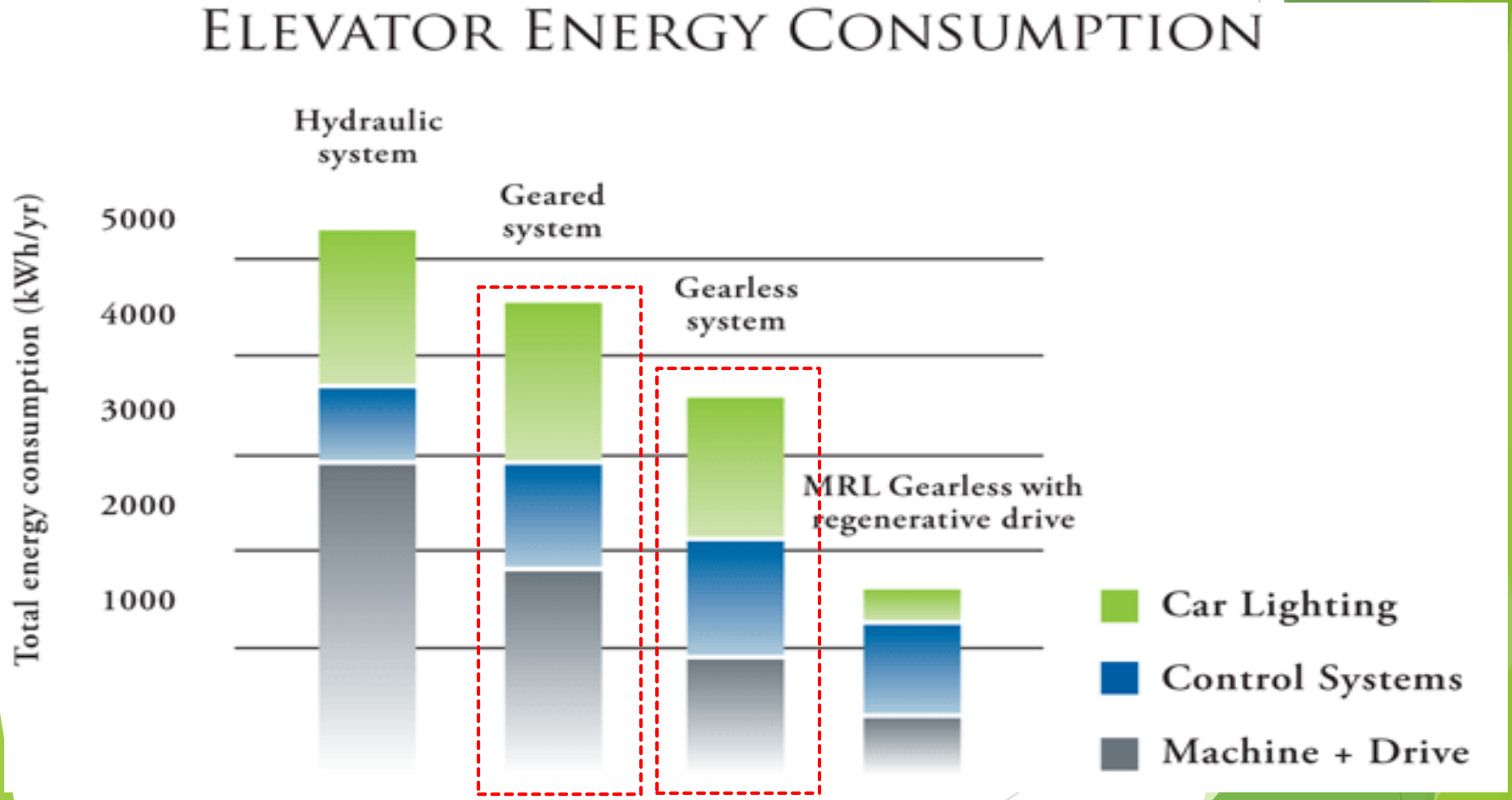




DCS control system

5. GEARLESS TRACTION MACHINE

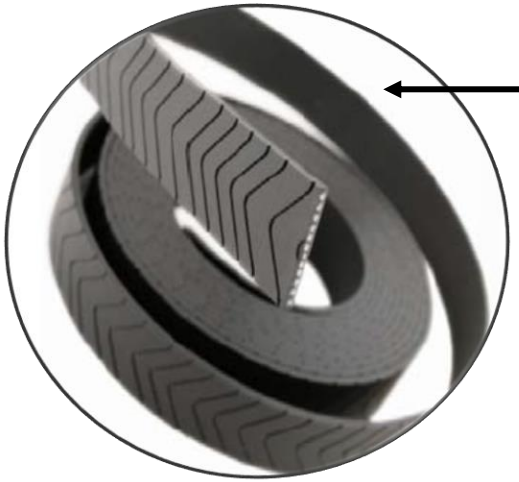
- Less friction, less energy loss (no gearbox) and more energy efficient.

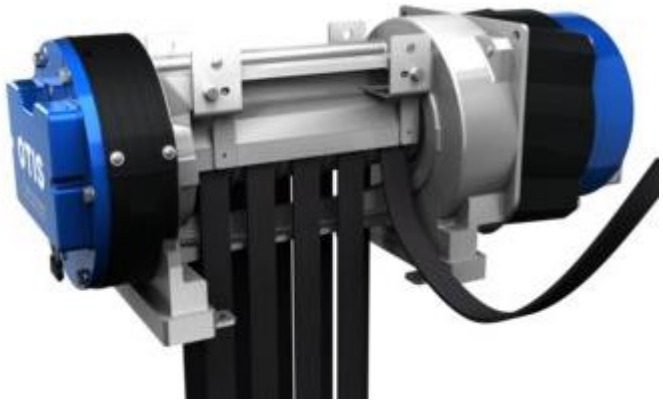


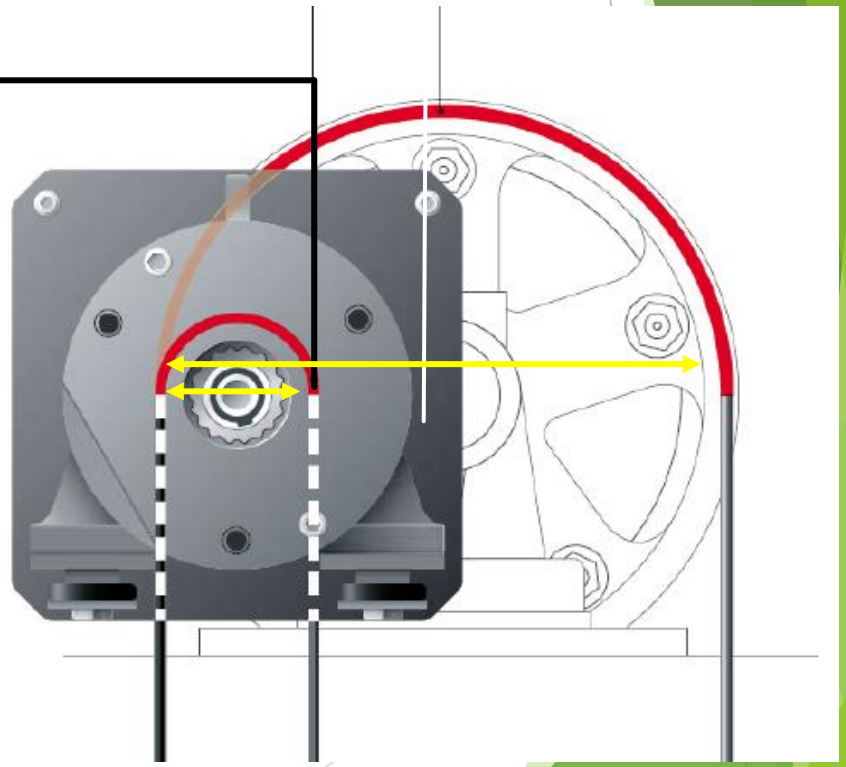
source: Otis Elevator Company

6. FLAT BELT

- Ultra-thin steel cables encapsulated in a polyurethane sheath.
- ~20% stronger, twice life-time of standard steel ropes.
- Less noise and vibration, no lubrication – environmentally friendly.
- Use of smaller traction sheave, smaller motor due to small wire rope diameter
- Normally 720mm sheave (wire ropes) can be reduced to 100 mm.

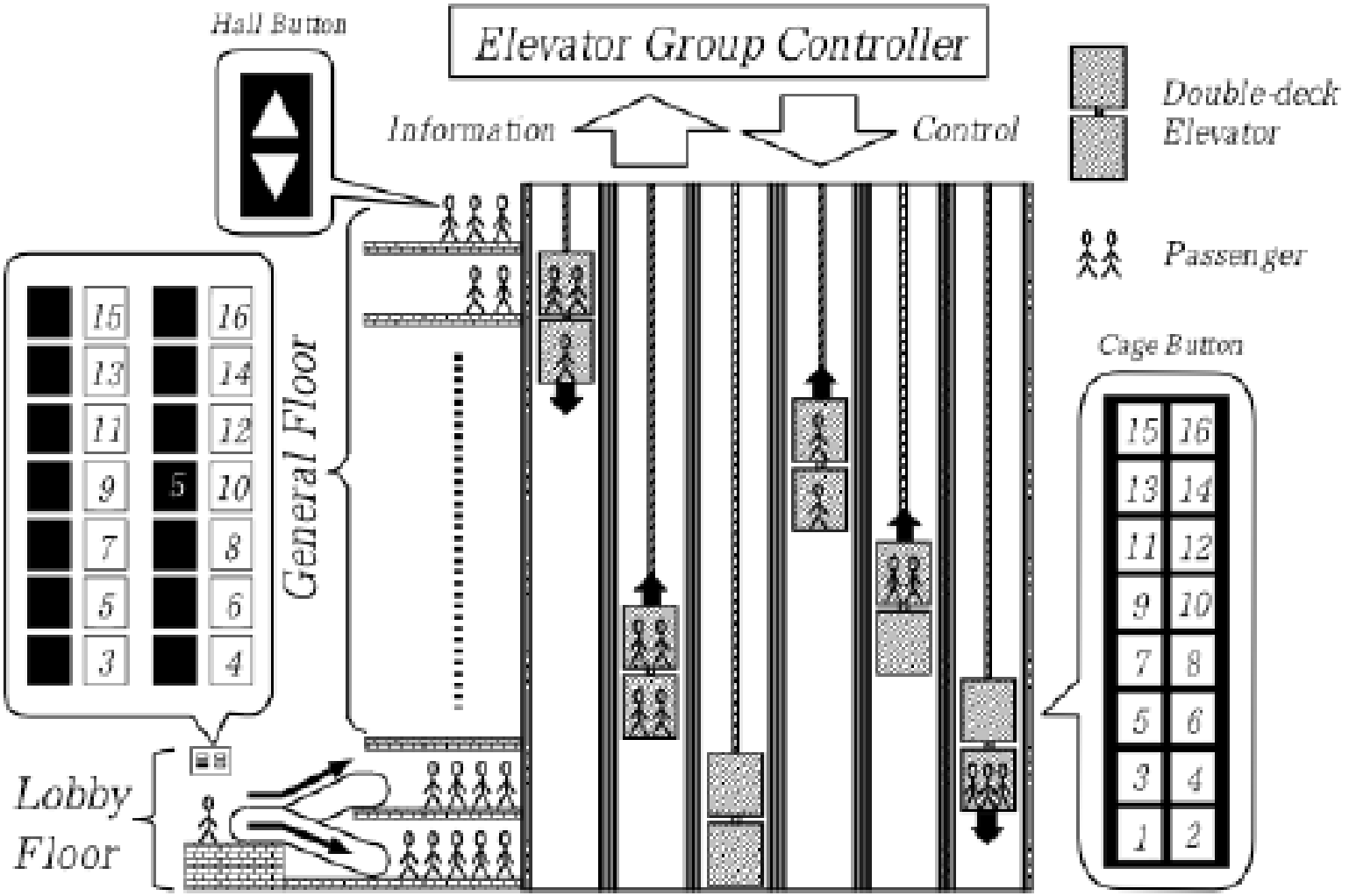






7. DOUBLE-DECK LIFT

- 2 cars attached together, one on top of the other.
- Allows passengers on two consecutive floors to be able to use the elevator simultaneously - significantly increasing the passenger capacity.
- Can improve efficiency in buildings where the volume of traffic would normally have a single elevator stopping at every floor.
- Can reduce number of lifts required in the building up to 45%.
- Suitable for >30 floors above buildings.
- Cost ~30% higher than single deck lift.


Hall Button
Elevator Group Controller
Information
Control
Double-deck Elevator
Passenger
Cage Button
General Floor
Lobby Floor
15
16
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14
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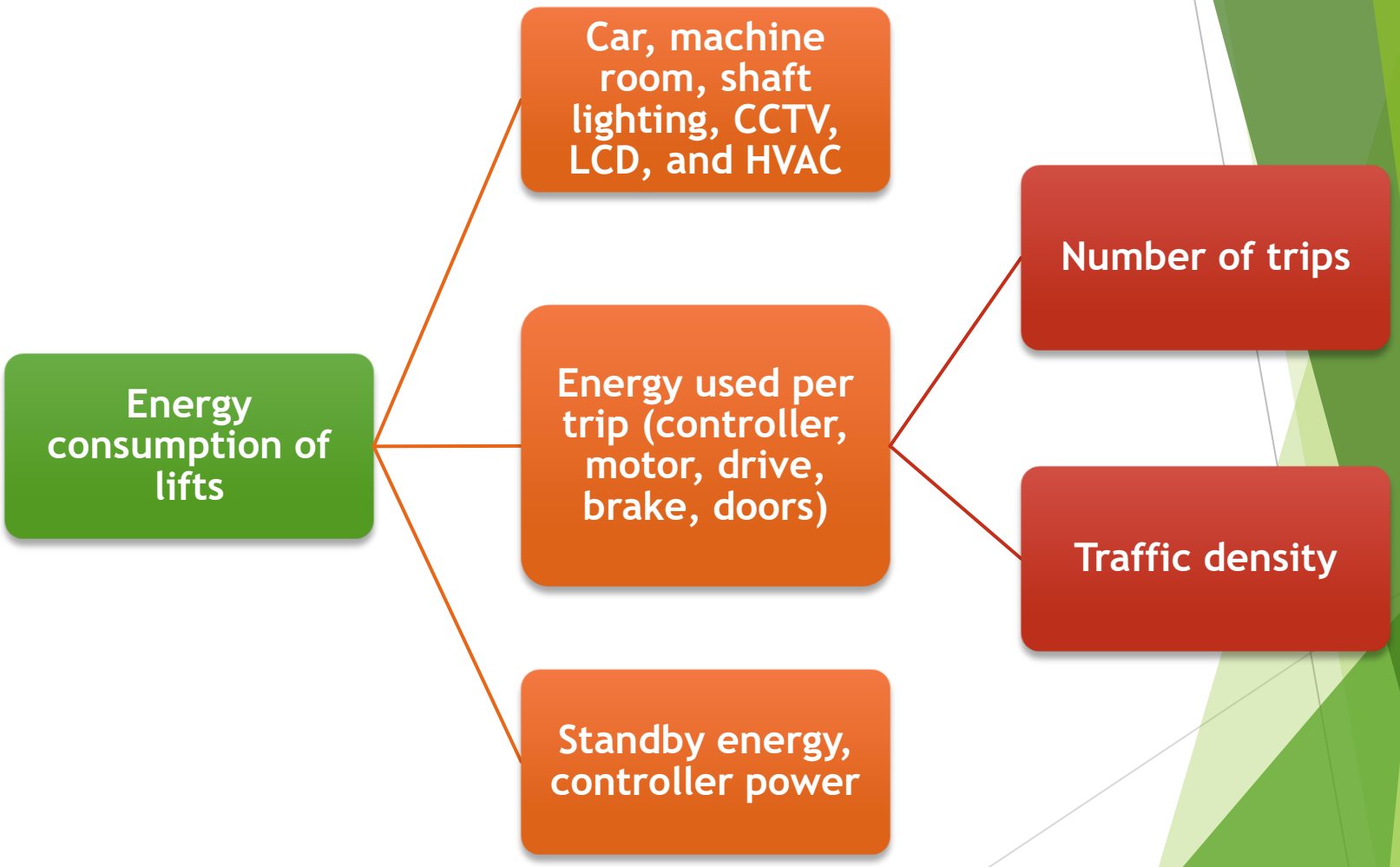
2

ENERGY CONSUMPTION OF LIFTS



HVAC – heating, ventilation, air conditioning

STRATEGIES FOR ENERGY EFFICIENT LIFTS

1. REDUCE STANDBY POWER OF LIFTS

- Worldwide research indicated that the duration of standby period is usually many times longer than the normal running period. As a result, the standby power/energy consumption can be as high as **95%** of the overall consumption in vertical transportation. (Sam C M Hui, 2016)
- On average standby times 3 times higher than travel time for vertical transportation. (De Almeida, et. al.,2012)
- Shut off unnecessary equipment when idling – lighting, ventilation, music, LCD display system.
- Use low energy standby power equipment – controller, call button, floor indicator, display, etc.

Lift Ref. No.	Building Type	Vertical Rise (m)	No. of Floor	Rated Load (kg)	Rated Speed (m/s)	Idle Power (W)	Standby Power in 5 min. (W)	Standby Power in 30 min. (W)	Annual Standby Energy (kWh)	Annual Running Energy (kWh)	Annual S/R Ratio
L1	Commercial	28.3	8	1600	1.6	394.0	246.1	157.5	2747	268	10.25
L2	Industrial	10.2	3	8200	0.5	2390.8	139.8	89.5	3597	2611	1.38
L3	Residential	7.0	3	750	1.0	1318.0	127.9	95.9	2358	299	7.88
L4	School	9.6	4	1800	1.0	1413.2	211.5	152.2	2447	79	30.97
L5	Industrial	4.6	2	4000	1.0	2438.5	117.8	81.3	5474	2310	2.37
L6	Industrial	4.6	2	630	1.0	1338.5	118.3	94.7	3322	591	5.62
L7	Railway	17.4	3	1800	1.0	341.4	167.7	119.1	7216	4078	1.77
L8	Commercial	13.5	3	1600	2.0	407.5	264.8	174.8	2301	1395	1.65
L9	Commercial	15.0	3	1800	1.0	278.0	158.5	112.5	1534	2014	0.76
L10	Commercial	12.1	3	1600	2.0	398.5	258.1	170.3	2254	4238	0.53
L11	Residential	11.0	2	900	1.6	1334.9	252.6	161.6	4859	2025	2.40
L12	Residential	152.8	46	900	3.5	2576.9	1288.5	811.7	13456	14740	0.91
L13	School	35.0	8	2000	1.8	1565.0	370.8	248.4	5914	7295	0.81
L14	Commercial	121.3	31	1800	3.0	2297.7	1122.5	684.7	11694	17012	0.69
L15	School	60.0	12	2000	1.8	1649.8	488.4	317.4	6311	15277	0.41
L16	Residential	60.3	13	1600	2.5	833.5	649.5	357.2	4496	4781	0.94
L17	Residential	13.3	6	1600	1.6	416.3	264.4	169.2	2220	5825	0.38
L18	Commercial	116.6	16	1600	3.5	2269.6	1091.1	741.9	10741	15326	0.70
L19	Railway	4.8	2	1000	1.0	424.2	118.7	84.3	1398	4394	0.32
L20	Commercial	5.1	2	1000	1.0	208.0	120.1	81.7	883	7631	0.12
L21	Residential	83.9	20	1600	4.0	2165.1	895.7	573.3	6107	20365	0.30

Annual running and standby energy consumption of the lifts

(source: Analysis of standby power consumption for lifts and escalators, Hong Kong, 2016)

2. LOAD BY-PASS FUNCTION

- Lift will not stop or respond to any call when the car load is ≥80%.
- Reduce the number of unnecessary stops - save time and energy.

3. ANTI-NUISANCE CALL/FALSE CALL CANCELLING

- All calls registered will be cancelled if it is not correspond to actual load in the car.
- Avoid unwanted operations due to false call.

4. CAR CALL CANCELLING

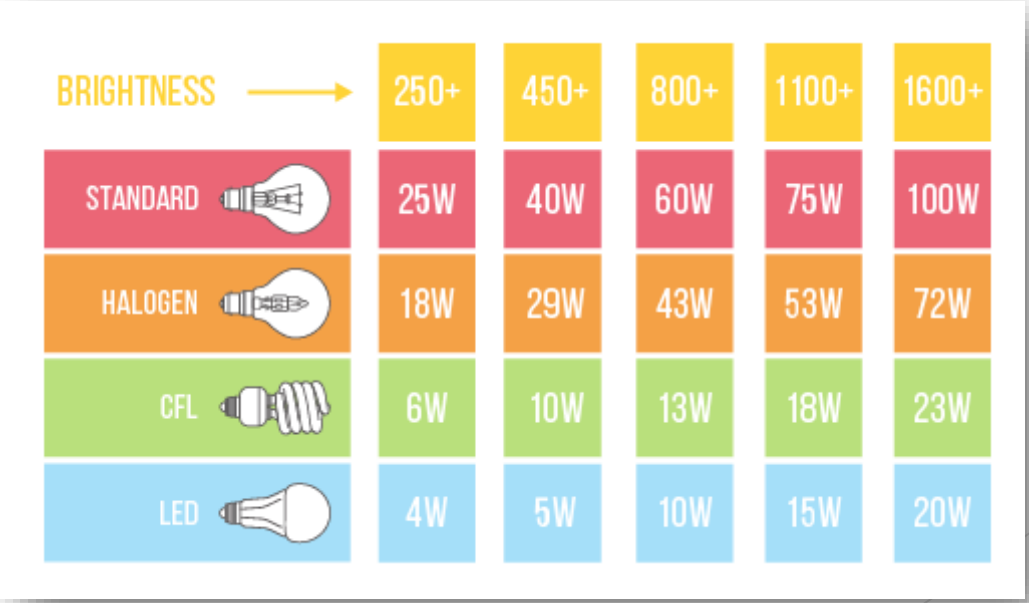
- Cancel the wrong pressed button.
- Save time and energy for unwanted operations.

5. ENERGY SAVING LIGHTING

- One of the most contributes to standby electricity.
- Use better luminous efficacy (lm/W) light to reduce energy consumption.

Type of Lamp	Lifetime (hours)	Luminous efficacy (lm/W)
Incandescent	750-2.000	10-18
Halogen incandescent	3.000-4.000	15-20
Compact fluorescent (CFL)	8.000-10.000	35-60
Linear fluorescent	20.000-30.000	50-100
High-Power White LED	35.000-50.000	30-150

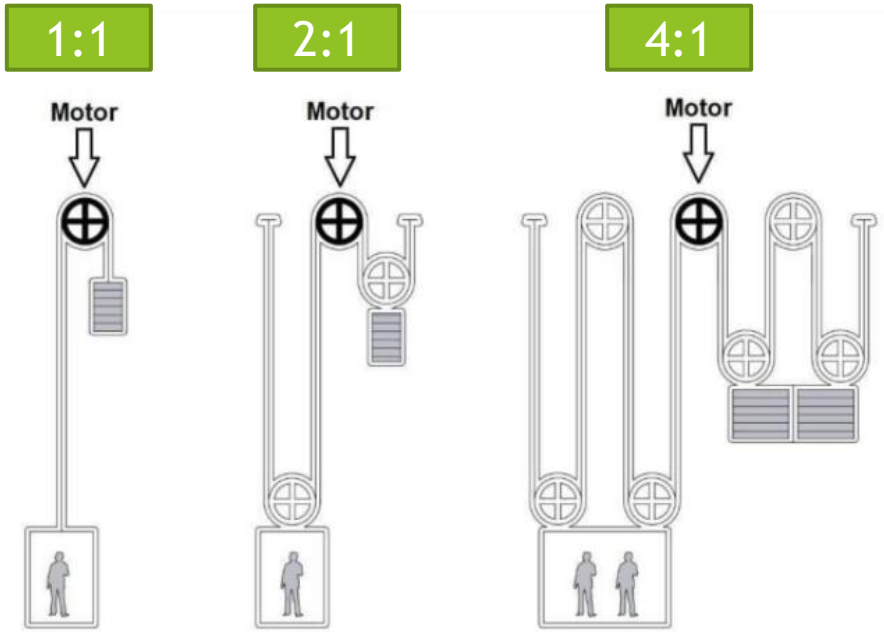
Comparison of lamp's characteristic
(source Sam C. M. Hui, Chor-Yip Yeung)

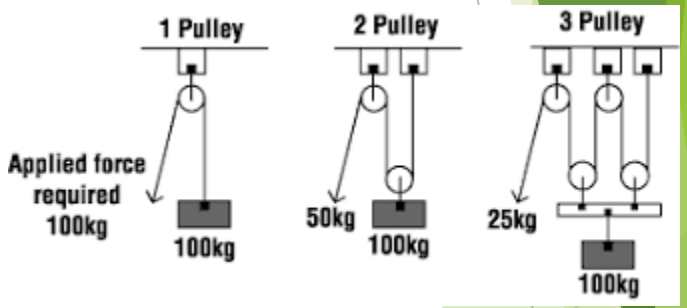


Comparison of lamp's lumens and watts
(source: Lindsay Wilson)

6. ROPING SYSTEM

- Different roping will have different impacts on energy consumption.
- 2: 1 roping require smaller motor - only require to produce half of the torque of 1:1 roping system.
- With 2:1 roping system, load on the rope is reduced by half, hence the diameter and number of ropes can be reduced too.



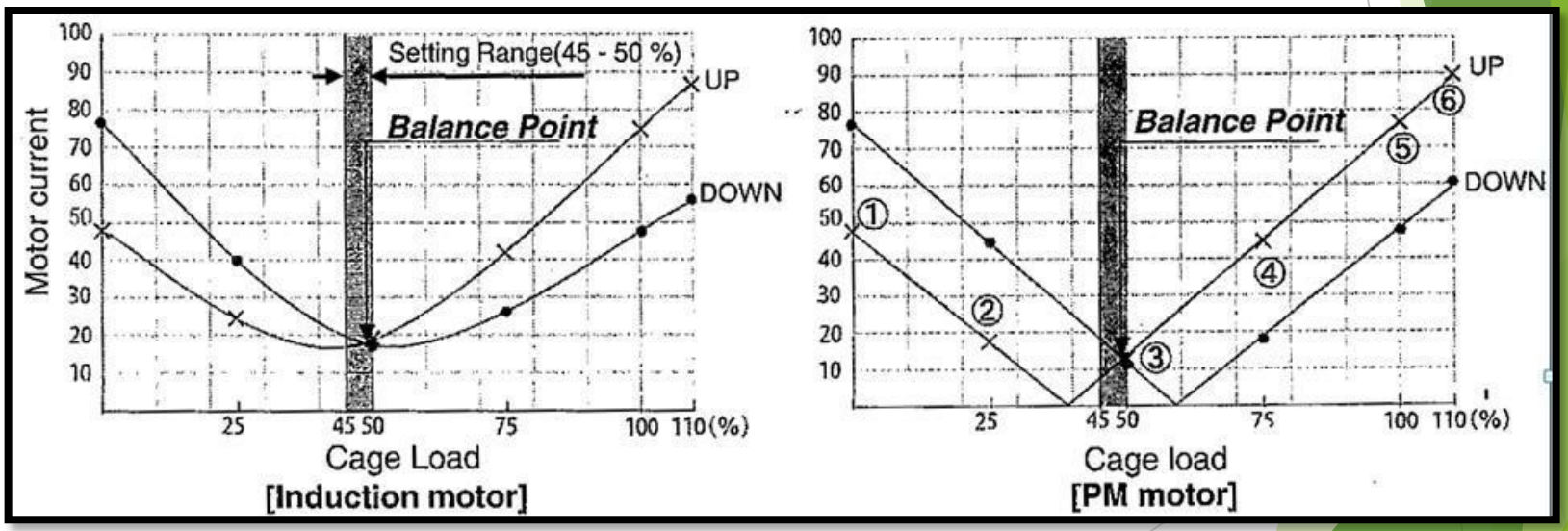


7. LOAD BALANCING

(i) To ensure the counterweight is roughly equal to the weight of the car plus 45-50% of the contract load.

(ii) If the elevator is properly balanced, the current readings during the upward and downward travels at 50% load should be the same.

(iii) Unbalanced car/counterweight put additional load to the motor hence will impact the energy consumption.



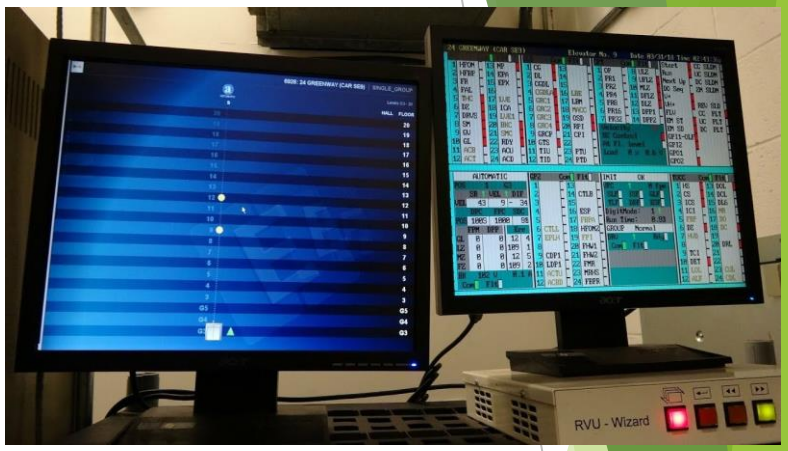
8. COMPUTERIZED ELEVATOR MONITORING SYSTEM

- Enable to monitor and control the lifts remotely such as shut off/on/park the lift, close/open/hold the lift door, floor lock out, VIP operation, faulty, maintenance, fire/emergency mode operation, etc.

- Show real time status of the lifts such as current floor, next destination, door open/close, parking, faulty, fire/emergency mode, etc.

- Scheduling of operations such as up/down peak during specific periods to meet the operation demand of the building.

- Show and generate statistical information such as fault logs, counts of call for each lift, waiting time, etc.



FUTURE LIFTS

1. TWIN by Thyssen Krupp

- Two lift cars in a shaft
- Less footprint – save 30-50% building space
- Move 40% passengers more compared to conventional lift
- Suitable for buildings > 50m

Source: Thyssen Krupp

FUTURE LIFTS

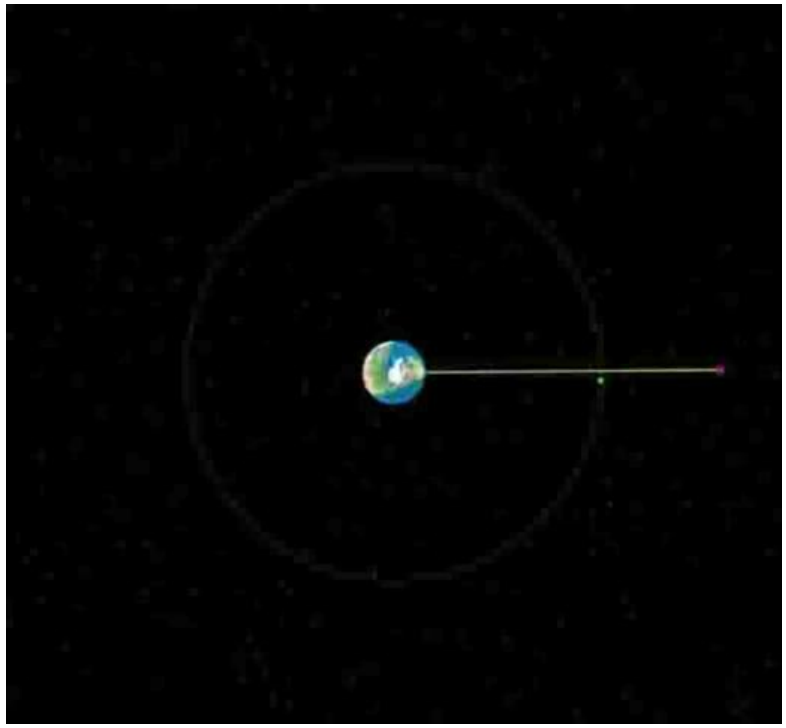
2. MULTI by Thyssen Krupp

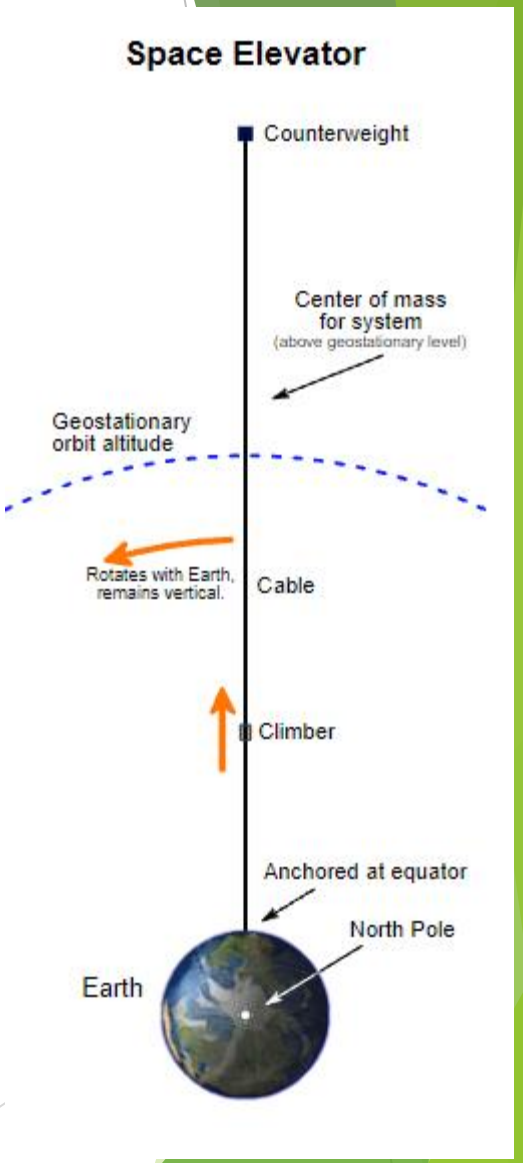
- Cable-less lift
- More flexible, less footprint - multiple lifts in one shaft
- Lift can travel vertically and horizontally
- Use linear motor technology
- powered by electromagnetic induction that causes magnetic levitation

Source: Thyssen Krupp

3. SPACE ELEVATOR

- Space elevator extend from a base tower approximately 31 miles (50 kilometers) tall attached to a geostationary satellite 22,236 miles (35786 km) above the Earth- NASA.
- Four to six tracks where electromagnetic elevator cars would be able to travel up to thousands of kilometers per hour.
- Expected to be built by 2050.





Source: nbcnews.com


Thank
You


GO green